

WHAT WE CLAIM:

1. Three dimensional recording and reproducing apparatus comprising:

a recording medium having N number of recording layers on a substrate;

a laser light source;

an optical system including a focus lens for focusing a light emitted from said laser light source on a  $k_{th}$  layer of said recording layers; separating means for separating the light reflected from said recording layer from said emitted light; and an image lens for converging said reflected light; and

photo detector disposed on a focal plane of said optical system and having an effective diameter D given by:

$$D = \lambda/NAI$$

where  $\lambda$  represents the wavelength of said emitted light, and NAI the numerical aperture of said image lens.

2. A three-dimensional recording and reproducing apparatus according to Claim 1, wherein a spot diameter  $Uk'$  of the light reflected from said  $k_{th}$  layer placed on said focal plane is given by:

$$Uk' = \lambda/NAI = \lambda fI/a$$

where  $fI$  represents the focal length of said image lens, and  $a$  an effective radius of said image lens.

3. A three-dimensional recording and reproducing apparatus according to Claim 1, wherein the following equation is satisfied:

$$0.1 \geq \sum [\delta^2_{jk} \cdot \alpha_{jk} \cdot (\Delta/U_{j'})^2]$$

where  $\delta^2_{jk}$  represents a ratio of the transmissivity of an arbitrary  $j_{th}$  layer to that of an arbitrary  $k_{th}$  layer;  $\alpha_{jk}$  a ratio of the reflectivity of the arbitrary  $j_{th}$  layer to that of the arbitrary  $k_{th}$  layer; and  $U_{j'}$  the diameter of a spot imaged on said focal plane when the light is converged on the  $j_{th}$  recording layer.

4. A three-dimensional recording and reproducing apparatus according to Claim 2, wherein the numerical aperture (NAF) of said focus lens, a distance (d) between said recording layers, and a maximum two-dimensional cycle value ( $b_{max}$ ) of a particular domain recorded on said recording layer satisfy the following equation:

$$b_{max} \leq 2d \cdot NAF$$

5. A three-dimensional recording and reproducing apparatus according to Claim 2, wherein inter-layer cross-talk components (f) between a  $j_{th}$  layer and said  $k_{th}$  layer is smaller than frequency components ( $1/b$ ) of recording marks recorded on said  $k_{th}$  layer.

6. A three-dimensional recording and reproducing apparatus according to Claim 2, wherein said wavelength  $\lambda$  satisfies the following equation:

$$\lambda/4 \geq (1/8NB)(1/NB^2 - 1)NAF^4\Delta d$$

where NB represents the reflectivity of said substrate; NAF the numerical aperture of said focus lens; and  $\Delta d$  a positional range in the optical axis direction in which exists a recording layer on which the light is to be converged.

7. A three-dimensional recording and reproducing apparatus according to Claim 2, wherein the intensity (P) of the light reflected from the recording layer furthest away from a light incident plane of said recording medium satisfies the following equation:

$$P \geq I_{k_{th}} \cdot S_k / \delta k$$

where  $I_{k_{th}}$  represents a threshold value of the light intensity density on the recording layer furthest away from the incident plane of said recording medium;  $S_k$  an area of the light spot when focused on the recording layer furthest away from the incident plane of said recording medium; and  $\delta k$  the overall transmissivity over layers between the light incident plane of said recording medium and said recording layer furthest away from the incident plane.

8. A three-dimensional recording and reproducing apparatus according to Claim 2, wherein said recording medium has one of a ROM (Read Only Memory) layer and a WOM (Write Once Memory) layer.

9. A three-dimensional recording and reproducing apparatus according to Claim 2, wherein said recording medium has a management format on said recording layers, and recording, after performed on said  $k_{th}$  layer, proceeds to another recording layer.

10. A three-dimensional recording and reproducing apparatus according to Claim 9, wherein said other recording layer is the  $(k + 1)_{th}$  layer.

11. A three-dimensional information recording and

reproducing apparatus comprising:

a recording medium including a plurality of stacked recording layers;

information recorded on said recording layers as local optical particular domains;

a focus lens for converging a light on each of said plurality of recording layers; and

a photo detector for detecting the light reflected from said recording medium,

wherein, when the light is converged on an arbitrary layer, a total area of local optical particular domains included in an area defined by the spot diameter on the adjacent layers is substantially constant.

12. A three-dimensional recording and reproducing method, using an information recording medium including a plurality of pairs of recording layer on which optical properties locally change due to a light irradiated thereto and an intermediate layer on an optically transparent substrate, wherein the optical properties of said plurality of recording film layers are changed individually of each other by irradiation of a light spot focused on said each recording layer to record information on said recording film layers, and the light is irradiated to said recording film layers, a reflected light or a transmitting light is imaged by an image lens, and changes in said local optical properties are detected by a photo detector to reproduce information, wherein

the refractivity and thickness of said

optically transparent substrate are represented by  $NB$  and  $d_0$ , respectively;

an intermediate layer and a recording layer are combined as a layer and first to  $N_{th}$  layers are designated from the substrate side;

a distance between the centers of adjacent  $k_{th}$  and  $(k - 1)_{th}$  recording film layers is represented by  $dk$ ;

the thicknesses of an arbitrary  $k_{th}$  recording layer and intermediate layer are represented by  $dFk$  and  $dMk$ , respectively, and the real parts of the refractivities of the same are represented by  $NFk$  and  $NMk$ , respectively;

a cycle of changes in the local optical properties on the plane of each layer is represented by  $b$  [ $\mu m$ ];

the wavelength of a light source in a focusing optical system is represented by  $\lambda$  [ $\mu m$ ];

The numerical aperture, effective radius and focal length of the focus lens are represented by  $NAF$ ,  $a$  [ $mm$ ] and  $fF$ , respectively;

The numerical aperture and focal length of the image lens are represented by  $NAI$  and  $fI$ , respectively; and

the diameter of a light receiving plane of the optical detector is represented by  $D$ ,

wherein the light focused on a  $k_{th}$  layer as a target layer and reflected therefrom is imaged on the focus position of the image lens, and a spot diameter  $Uk'$

on this focal plane is given by:

$$Uk' = \lambda/NAI = \lambda fI/a.$$